Mining for Salt in European Prehistory

Anthony Harding

Department of Archaeology, University of Exeter, Laver Building, North Park Road, Exeter, EX4 4QE, United Kingdom
e-mail: a.f.harding@exeter.ac.uk

Abstract: Salt was produced in a number of ways in ancient times. Evaporation using briquetage was the commonest, but mining or quarrying rock salt is better known, especially from the famous mines at Hallstatt (Gmunden district) and the Dürrnberg (Hallein district). One of the richest areas for salt is the Carpathian zone; the article describes the results of recent fieldwork in Romania, where a technique using wooden troughs and wattle-framed ponds was used. It is argued that a form of open-cast mining was employed, the troughs used to assist breaking up the rock salt surface, and perhaps also to facilitate concentration of brine.

Keywords: Salt mining, Hallstatt, Romania, troughs, brine

Jacek Lech's many fundamental contributions on flint mining raise interesting questions about mining in general and in particular mining for other materials, and mining at periods other than the Neolithic. In this contribution in his honour I would like to turn my attention to the question of mining for salt. For a Polish archaeologist, salt mining might seem to be nothing out of the ordinary, given the evidence for the practice in the mines of Little Poland, most obviously Wieliczka (Cracow district) but also Bochnia (Cracow district) and other places, and in great Poland, at Kłodawa (Koło district) and Inowrocław (Inowrocław district). But the situation is more complicated than that, as I would like to explore in these pages.

The famous mines of Hallstatt (Gmunden district) are the best known examples from prehistory, and also those that have provided the most extensive evidence for both Bronze Age and Iron Age salt mining (Kern *et al.* 2009). Colleagues from the Naturhistorisches Museum in Vienna, under the present-day leadership of Anton Kern but in previous years Fritz-Eckard Barth, have unravelled a complex history, with different techniques being used in Bronze and Iron Ages (Barth 1982, 1998). No story of salt mining would be complete without proper consideration of Hallstatt; but that is a task for the Vienna team. Likewise the work of Thomas Stöllner at the Dürrnberg, near Hallein, would require a separate paper for full consideration; his work is already fully published (Stöllner 1999, 2002). Stöllner has also worked on salt mines in Iran (Aali *et al.* 2012), as has Catherine Marro (2011) in Azerbaijan; this important work should also be included in a full consideration of the matter. But here I can only cover those aspects of salt mining where I myself have made a contribution, as well as some general considerations.

Mining for rock salt is only one of a number of techniques for obtaining salt, at the present day as in the past. In areas where solar energy is strong enough, for long enough in the year, that was what was used: this is the invariable situation around Mediterranean shores, for example, where salt lagoons or pans are very common. Many concerns, both small and large, operate in this fashion at the present day; and it was this technique which was used in Roman times, for instance on the Tyrrhenian coast of Italy near Ostia (for supplying Rome), and in Etruria (for the Etruscan cities). It has also been suggested that this would have happened around Baltic shores (Jaanusson and Jaanusson 1988), though there the strength of the sun would not have been strong enough other than in high summer for effective evaporation of sea water to occur without additional help (see following). In other places salt is easily obtainable from salt lakes, in western Asia most famously the Great Salt Lake (Tuz Gölü) of Anatolia.

More common in ancient times, and certainly in prehistory, was the use of artificial heat to bring about the evaporation of salt water, whether seawater or brine from inland springs. This technology involves the use of the coarse ceramic known as briquetage, a term which was originally used to apply both to the furnace installations and to the containers and pedestals which were integral parts of the process. Brine would be introduced into these containers, fires lit underneath, and the brine boiled until crystals could be easily removed; a range of variations on the technique are known, but the essentials are common to all the instances known. Boiling of seawater is commonly known from the east coast of England and the Atlantic and North Sea coasts of France and Belgium (Stopes 1879; Gouletquer 1970; Fawn *et al.* 1990; Thoen 1990; Daire 1994; Prilaux 2000; Lane and Morris 2001; Daire 2003; Prilaux *et al.* 2011); the most prolific instance of the boiling of brine from springs comes from Lorraine, where the valley of the river Seille is extraordinarily prolific in enormous briquetage sites (Bertaux 1976; Olivier 2005, 2010).

There are other techniques known for producing salt, for instance the burning of halophyte vegetation and the collecting of the crystals that form, or techniques involving the heating of material from salt marshes; these are attested ethnographically, and appear also to find counterparts in the accounts of the ancient authors, notably Pliny the Elder (Natural History, Book 31: 39–42). But in terms of quantity of salt produced, it is likely that nothing could compare with that available from the mining of rock salt (halite). So it is to this that I now turn.

The Vienna team has charted the techniques used at Hallstatt in great detail, demonstrating that what happened in the Bronze Age was different from that in the Iron Age. But the elaborateness of the installations attests to both its importance in local economy and society, and the volumes which must have been produced. Estimates have been made of various aspects of the Hallstatt mining process, and not only the volumes of salt (Kowarik 2009; Kowarik and Reschreiter 2010). The extraordinary preservation of organic material inside the mines will provide work for archaeologists, and food for thought, for many years to come. Now, however, I turn to a different area.

Romania has one of the biggest stores of accessible salt in Europe. In several parts of the country there are large outcrops and in many more there are underground salt domes (diapirs) which feed the brine springs that appear on the surface. The largest salt mine in Europe is the Unirea (Unification) mine at Slănic Prahova in Wallachia, 90km north of Bucharest, and only a few kilometres from Drajna de Jos on the Teleajen river with its tributary the Drajna stream. I mention this because Drajna de Jos is the findplace of one of the largest hoards of Bronze Age bronze objects in Romania, and because the river is salty there; Romanian scholars have long maintained that such massive hoards are found in the areas where salt is most abundant. Other mines, working at present or until recently, include those at Tîrgu Ocna, Praid, Cacica, Ocna Mures**,** Ocnele Mari, Dej and Turda. These mines, however, are all deep mines, and extend to depths far beyond what would have been possible for ancient miners.

Mineral extraction in ancient Dacia is well attested, and has been extensively studied by generations of scholars, in recent times most notably by Volker Wollmann, whose pioneering work on mining and mineral extraction in Roman Dacia is justly famous (Wollmann 1996). For the Romans, Dacia was an important source for metallic minerals, as finds at a number of sites have shown (for instance at Roşia Montana in the Apuşeni Mountains in Alba county). There is no question that deep mining took place for gold at that site, and for gold and other minerals at other places. When it comes to salt, however, Wollmann relied on a finding made in the 19th century at a place north of the river Tisza in what is today Ukraine, then known as Királyvölgy or Königstal (Preisig 1877). Recent study of these finds, by myself among others (Harding 2011), has shown that they belong with a group of objects now known much more extensively from recent work on salt sites, which I shall describe below. They relate not to deep mining, but to extraction from the surface.

Any kind of deep mining is difficult and dangerous, salt mining no less than that for metal minerals. One factor which is not often appreciated is that rock salt is very hard; certainly harder to work than, for instance, the dolomitised limestone that represents the matrix at the Great Orme copper mine in North Wales. As stated by Andrew Lewis in his MPhil thesis on the geology of this mine, 'Particular areas within the zone of dolomitisation are seen to have undergone a degree of disaggregation [rotting] producing a loosely bound granular rock that readily disintegrates to produce a sandy deposit... Here the dolomite [is] very friable, often crumbling away to a yellow-brown granular sand and easily removed by gentle scraping with a piece of wood, bone or even the finger nail' (Lewis 1996). Of course not all rock matrices around minerals were as soft as this; but one should not underestimate the hardness of rock salt. At the site of Băile Figa in northern Transylvania, Bistriţa-Năsăud county, which I shall discuss below, the salt was so hard that even a bulldozer could only scratch the surface with the teeth of its bucket; and a local villager, working with a cast iron axe, took at least 15 minutes to detach a modest lump of salt when working (strictly unofficially!) on the salt surface in the village of Dumitra (also in Bistriţa-Năsăud county).

Now this has important implications for how salt mining might have been carried out in prehistory. At Hallstatt picks were used to detach chunks of rock from the working face by creating parallel rills on the rock face (in the Bronze Age), and heart-shaped forms in the Iron Age; the former enabled smallish pieces to be detached, the latter very sizeable pieces, apparently up to 100kg (though the largest actually recovered in excavation weighs 42kg). In Romania it is possible in many places to do the same without digging shafts or tunnels into the rock, as peasants do at the present day (I have observed them doing it at both Praid in Transylvania and in Bisoca commune on the border between Wallachia and Moldavia). Here, and in many other places where the salt appears as massive outcrops (Fig. 1), it is possible to collect pieces of rock salt armed only with a sledge-hammer. This working on the surface should be called quarrying rather than mining, a term which implies digging beneath or into the ground surface. This raises the question of how common the Alpine tunnelling technique was, as opposed to working on the surface,

Fig. 1. View of a salt massif in Bisoca commune, Wallachia, Romania. Photo: A. Harding.

or at least removing the overburden so as to expose the rock salt underneath, and then working it directly – what we would nowadays call open-cast mining (German *Tagebau*).

This question is raised by the work which Valeriu Cavruc (Valerii Kavruk) and I have carried out at Băile Figa in northern Transylvania, near the town of Beclean on the Someş river, in Bistriţa-Năsăud County. Our work up to 2012 is published (Harding and Kavruk 2013); continuing small-scale excavation since then has produced many interesting findings, but for present purposes the work done up to 2012 conveys the necessary information. The site, lying in a small enclosed valley, is crossed by a salty stream, rising at a spring at the southern end; the entire area is around 400m long south to north, and 200m east to west (though the flatter part of the valley bottom is much less than this). It overlies a salt dome or diapir, from which the spring rises. Much of the site's surface is covered with mounds and depressions, which the locals know as diggings for salt in 'Turkish' times (i.e. the period when the area was a vassal principality within the Ottoman Empire, approximately the 16th and 17th centuries).

Excavation showed that the rock salt surface lies some 2 to 2.50m below the modern surface, in the places where it has been encountered; probably deeper in some places (though not much deeper, given the level of the water-table, which would prevent any surface working without pumping). In the northern excavation area, wooden posts and other constructions were encountered lying directly on the rock salt. In the southern area, a roughly square wood-framed shaft is presumed to have represented a means of access to the rock face, though excavation could not proceed so deep because of standing water and the progressively more confined space in which to work. Nearby was an unlined pit containing a well-preserved ladder 4.50m long (Fig. 2); this pit could also not be dug out down to the rock, but the length of the ladder gives us an indication of how deep the pit must have reached below the contemporary ground surface. Both the wood-framed shaft and the ladder date to the pre-Roman Iron Age. The presumption has to be that the salt workers used these facilities to get down to the rock, where they worked to remove pieces of rock, which were then taken up and manipulated further.

What was the nature of that subsequent work? Rock salt needs extensive treatment before it can be conveniently used for human consumption; fine grinding if the salt is very pure (which is often not the case); or dissolving in fresh water and then recrystallizing through evaporation. Given the presence of wattle-framed ponds and pools in the excavated area, we believe it was the latter which took place; pieces of rock salt would be placed in these ponds to form brine, which could then be led into other installations for evaporation.

This is not the whole story, however. A series of wooden troughs, up to 3m long, has been found at Figa and other sites (Fig. 3); these have perforations in the bottom, filled with wooden plugs. Speculation has taken place over the years as to how these functioned; experiments in 2009 and 2010 seem to confirm one early theory, that fresh water would be allowed to drip through these perforations on the rock salt surface, forming depressions into which wedges could be driven, producing fractures in the rock. If this is the case, we have a solution to the problem which must have faced ancient miners: how do you break up such a hard rock with the tools available (in the Bronze Age at least, no iron, and no cast iron until a later date, perhaps the Roman period). While so-called 'mining tools' (German *Rillenhämmer*) have been found at Figa, they are quite small and do not seem well suited to the heavy work involved in breaking up rock; but they might be quite suitable for crushing small pieces of rock that had already been broken from the matrix. The dripping of water from the bottom of the troughs has now been shown to be helpful in achieving the initial

Fig. 2. Excavated area at the southern end of the Băile Figa site, Bistriţa-Năsăud County, showing ladder in situ. Photo: A. Harding.

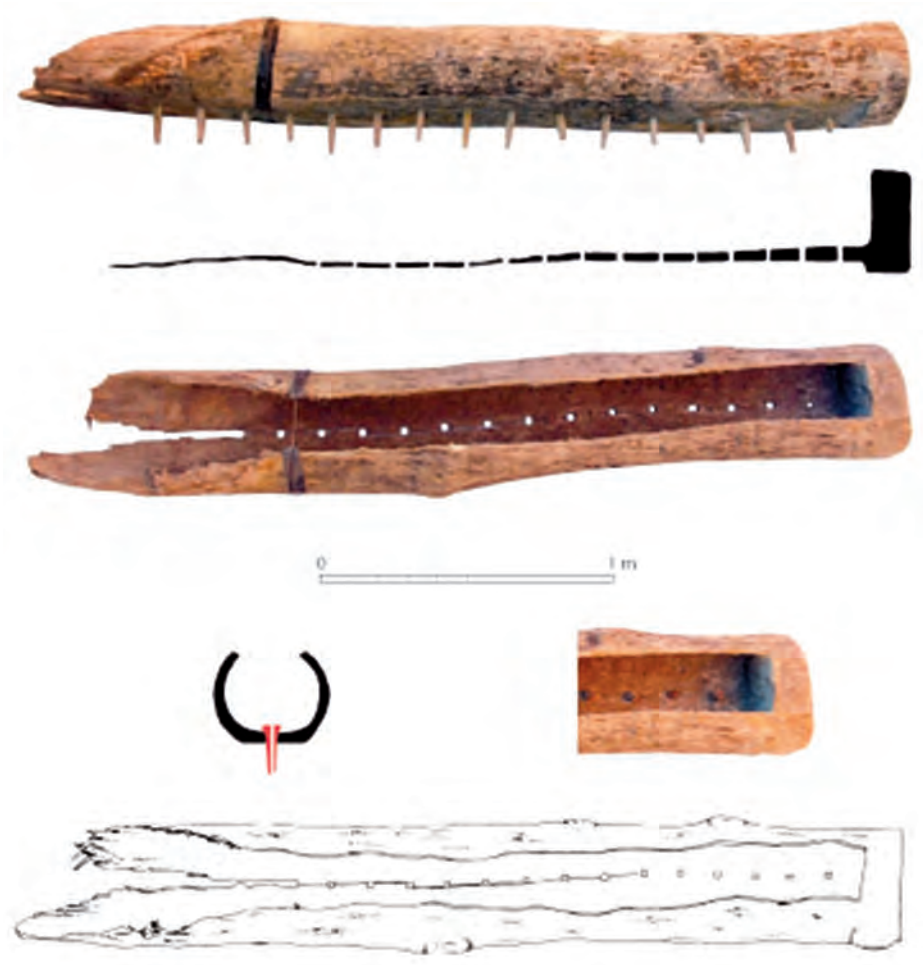

Fig. 3. Wooden trough extracted in 2005 at Băile Figa, Bistriţa-Năsăud County. Drawn: Museum of the Eastern Carpathians (Sfantu Gheorghe, Romania).

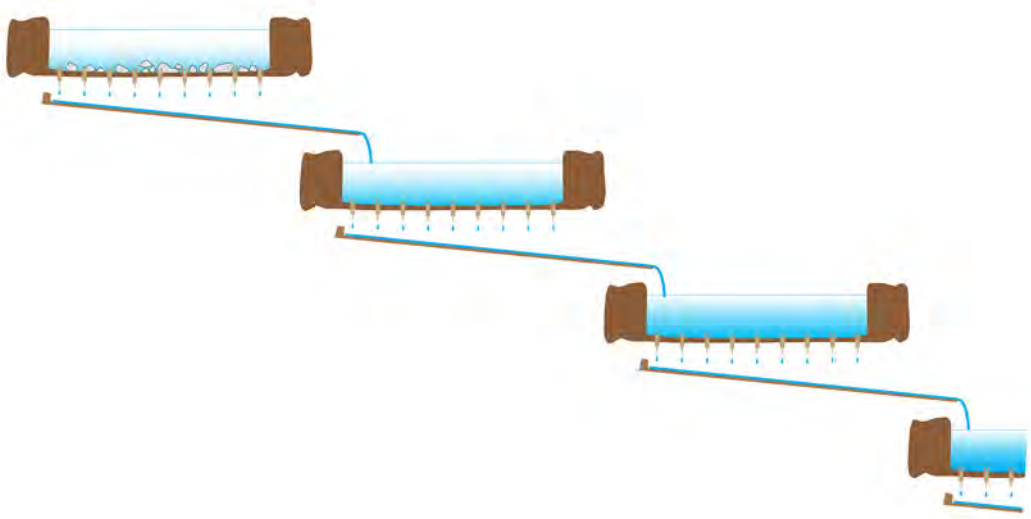

Fig. 4. Diagram showing possible method of using wooden troughs in sequence. Drawn: S. Goddard.

fracturing of the rock. In passing I should mention that no evidence has been found for fire-setting at Figa, nor as far as I know at Hallstatt.

Another theory for the use of the troughs emerges from the fact that where they have been found in context, they seem to come not singly but in groups. This was especially the case in Trench XV at Figa, where no less than five troughs have been found, more or less in a line. In other locations too troughs were found in pairs or groups. This leads to the suggestion that they worked in sequence, not individually; and the most likely explanation for that is that brine was progressively concentrated along the line, dripping from one into the next (Fig. 4). This brine would have been created by putting the detached pieces of rock salt into the first trough in the line, filling it with water, and letting the resultant salty water mixture drip through to the next. The flow could be controlled by plugging the holes in the wooden plugs, so that brine could accumulate in one trough before being released to drip, in increasingly concentrated form, to the next.

If this theory is correct, the technology at which we are looking at Figa and similar sites is a form of quarrying that involved extracting pieces of rock from the exposed surface (i.e. essentially open-cast mining). I suspect that such a set of techniques was rather more common in prehistory and early history than we have hitherto believed, because it is hard to spot and easy for its traces to be obliterated over the centuries.

One other site in the same region deserves mention: a stream valley north of the village of Săsarm, also in Bistriţa-Năsăud county, but north of the Someş river, 7.5 km north-west of Figa (Fig. 5). Here another salt stream runs downhill, past a brine well and an area

Fig. 5. View of the salt stream at Săsarm, Bistriţa-Năsăud County. Photo: A. Harding.

containing prehistoric and medieval pottery, to join the Someş a couple of kilometres to the south-east. The valley contains numerous wooden structures, some apparently modern, some ancient (radiocarbon dates and dendrochronology have confirmed a Bronze Age date for some timbers that are deep set in the stream bed). All along the north side of the stream

are depressions, some containing what are evidently supports for adits going in to the valley side. The date of these is unknown at present. But if some turn out to be ancient rather than modern, mining based on tunnelling rather than open-casting would be confirmed. If that is the case, then not all salt mining in Romania was open-cast – but probably not deep mining either.

Seen in this light, salt mining on the sites of eastern Europe was nothing like what we find in modern salt mines, whether in Romania, Poland, Siberia, or anywhere else. It was no doubt still difficult and dangerous work, and constant working with salt always brings with it damage to the skin, though not so dangerous as venturing underground in cramped, wet and smoky tunnels, with the constant threat of collapse looming over one. The precise technologies which were employed are still not fully understood, especially that involving the wooden troughs. But I think it is clear that the term 'salt mining', in the 19th and 20th centuries indelibly associated in our minds with Russian penal servitude, was in fact something that involved a range of more benign activities; in Romania at least, 'miners' were quarrymen, and though they had to cope with the exhausting work of breaking up very hard rock, in wet conditions, the results were probably highly successful in terms of quantity, and perhaps quality. For it was the sources of Transylvania which must have supplied many areas outside that province, notably the villages and towns of the Hungarian plain which are entirely without natural salt sources, but probably also areas much further afield. This was production on an industrial scale, not to be matched again until the great briquetage sites of the Seille valley came on stream in the Early Iron Age.

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